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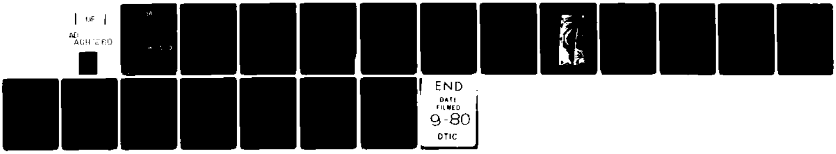

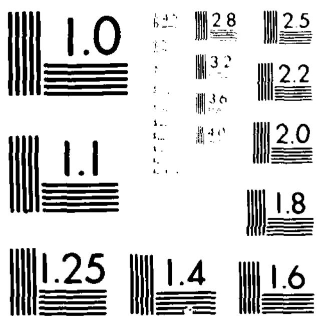

MICROCOPY RESOLUTION TEST CHART

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Data Collection Methods for Sand Inventory-Type Surveys

by

Dennis A. Prins

COASTAL ENGINEERING TECHNICAL AID NO. 80-4

MARCH 1980

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COASTAL ENGINEERING RESEARCH CENTER
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During recent years the shallow areas of the Continental Shelf have been found to be a potential source for suitable sand for beach-fill projects. This report describes the techniques and methods used in the planning and implementation of the data collection effort associated with surveys conducted to locate and delineate offshore sand sources for beach-fill projects.

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PREFACE

This report describes the methods used in the planning and implementation for the data collection part of a sand inventory-type survey, based on both contract and inhouse field data collection experiences. The work was carried out under the field data collection program of the U.S. Army Coastal Engineering Research Center (CERC).

This report was prepared by Dennis A. Prins, Physical Scientist, under the general supervision of Dr. Craig H. Everts, Chief, Engineering Geology Branch, Engineering Development Division.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

TED E. BISHOP
Colonel, Corps of Engineers
Commander and Director

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FIGURES

CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.852	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.01745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

DATA COLLECTION METHODS FOR SAND
INVENTORY-TYPE SURVEYS

by
Dennis A. Prins

I. INTRODUCTION

Beaches throughout the United States serve as primary areas of recreation and as protective areas in the natural transition zone between the water and land masses. During recent years, Federal, State, and local governments have been under increasing pressure to maintain and improve these valuable areas. This pressure has largely been caused by the loss of large volumes of beach sand because of erosion.

One method of maintenance and improvement of eroding beaches has been the placement of sand of suitable grain size, sorting, and composition. However, beach restoration requires large volumes of sand. The sources of suitable sands in sufficient volumes from lagoons, wetlands, and inland sources are becoming increasingly difficult to obtain due to increased real estate value, environmental and ecological constraints, and the depletion of nearby sources (Williams, 1976). Also, the cost of transporting sand from land sources to project beaches has increased tremendously in the last several years.

Shallow areas of the Continental Shelf are a potential source of suitable sand for beach-fill projects and of aggregate for construction purposes. In some cases the offshore mining of these sands and gravels has become economically feasible. This report describes the planning requirements and methods presently used in collecting data to locate and delineate areas of suitable sand sources for use in beach-fill projects.

II. SURVEY TECHNIQUES

1. Essential Data.

A minimum of the following three types of data are required: medium- to high-resolution seismic reflection profiles, horizontal position control, and 20-foot-long (6.1 meters) sediment cores. The seismic reflection profiles are obtained by generating high-energy acoustic pulses near the water surface, which are reflected from the subbottom interfaces, and recording the acoustic return signal on a continuous paper chart. The compositional and physical properties of the sea floor and subbottom sediments at various depths produce acoustic contrasts which appear as lines on the records (Fig. 1) (Duane and Meisburger, 1969).

Horizontal position data are usually obtained using an electronic positioning system. The position (fix) of the vessel is recorded at frequent intervals (usually every 2 to 4 minutes) and is simultaneously recorded and labeled on the seismic reflection record by an event mark. For this type of operation a positioning system is required with an accuracy of about 10 feet (±3.0 meters). Systems with this accuracy usually operate on the principle of pulse radar and are limited to line of sight. The basic system consists of a master unit mounted aboard the survey vessel and two shore stations. Each navigation fix

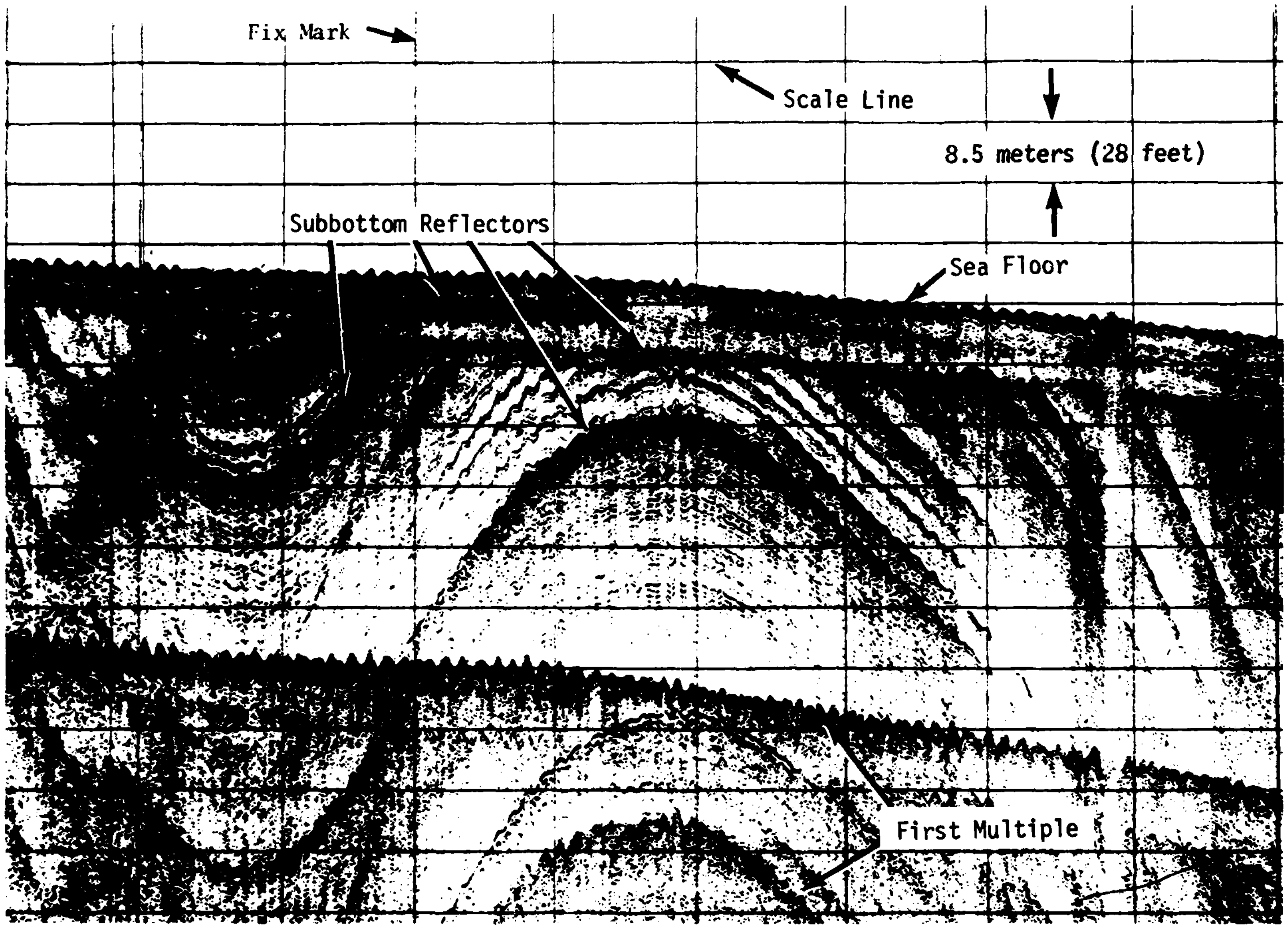

Figure 1. Section of seismic record taken off the coast of southern California.

is determined by the distance (range) from each of the two shore stations to the survey vessel and this range information is displayed on the onboard master unit. The geographic (horizontal) position of the shore stations must be known for the position of the survey vessel to be plotted by trilateration (solved by using three sides of the triangle). This can be done by using an automated plotter interfaced with the positioning system or by using a programable calculator and manually plotting the fix locations on a map or navigation chart.

The seismic reflection records are supplemented by cores of the subbottom sediment. The sediment cores are usually collected where the subbottom reflectors are within the penetration range of the cores. Cores are correlated with the subbottom reflector data. Sediment data can thus be areally extrapolated to provide a measure of continuity between cores. This, in many cases, allows mapping of the general subbottom structure of the study area.

Although not essential, side-scan sonar data collected simultaneously with the seismic data are very useful. Side-scan sonar is an effective method of illustrating surface geologic features and sea floor configurations such as sand waves, rock outcrops, areas of scour and deposition, as well as bottom hazards and potential archeological sites. In some cases it also determines if a sand body is active; i.e., actively affected by waves and currents. A fathometer should be used during coring operations to record water depth information at core site locations. Additional informtion on sediment composition between coring sites can be obtained by using a bottom grab sampler.

2. Essential Equipment.

In addition to the essential seismic profiling system, horizontal positioning system, and a coring device, various other types of equipment are required to conduct the survey. A suitable survey vessel is needed to accommodate the seismic and positioning equipment and other instruments that may be used, such as side-scan sonar and a fathometer, during data collection. Radios are required for a communications link with the survey vessel and shore personnel assigned to the positioning system shore stations. Vehicles are needed by the shore personnel when periodically relocating the shore transponders used with the positioning system.

During coring operations a platform is required for the coring device, an air compressor, and a crane to deploy the coring device. The coring platform must be a boat large enough to accommodate the equipment--a tug and barge arrangement, or a self-propelled barge (standard or jack-up type). A reconnaissance vessel should be used to deploy buoys or floats at the core sites. A small reconnaissance craft with the positioning system aboard has greater maneuverability when attempting to match or duplicate range values of previous position fixes. However, this is not required if a fully automated positioning system with a real time plotter and steering indicator, which allows for steering on a direct course to the desired location, is aboard the coring platform.

Appendix A contains a list of equipment and specifications of the various components of essential equipment plus other auxiliary equipment normally used with these surveys.

III. SURVEY PLANNING

1. Amount of Data.

The amount of data to be collected depends on several variables: dimensions of the geographic area to be surveyed, zones within the survey area where more detailed subbottom information is desired, and most important, the survey budget. It is good policy to investigate the possibility of existing data in the area of interest which might compliment or even reduce the amount of data needed for the survey. This can be done by contacting other agencies (e.g., National Oceanic and Atmospheric Administration (Sea Grant) and U.S. Geological Survey) and universities involved in coastal research and also by conducting a literature search.

Predetermined seismic survey tracklines are laid out, usually in two basic trackline patterns, on a hydrographic chart to sufficiently cover the survey area. The grid-line pattern is used to cover areas where more subbottom detail is required; e.g., areas suspected of containing desirable quantities of sand. In areas where the subbottom geology and bottom topography are suspect of a high degree of variability, the grid should be more closely spaced, i.e., 0.5-mile (0.8 kilometer) spacing. The grid lines may be spaced at greater intervals, i.e., 1-mile (1.6 kilometers) spacing if the subbottom geology and bottom topography illustrate a low degree of variability. One or more shore-parallel or a zigzag reconnaissance line usually provides sufficient coverage between the grided survey areas. This pattern, in many cases, will illustrate buried stream channels or other subbottom structures which might require further investigation (see Fig. 2). Tracklines should be plotted on navigation charts which show hazards to navigation so that these hazards can be avoided by the survey vessel.

Depending on the degree of variability of the subbottom geology and the bottom topography, the ratio of cores to seismic trackline mile should range from 1:6 (1 core per 6 trackline miles) to 1:10; i.e., the higher the degree of variability the higher the core to trackline mile ratio (Williams and Duane, 1972). Preliminary core locations may be selected while plotting the tentative seismic tracklines; however, final site selection should be based on the results of seismic records. Core sites should be selected as close as possible to the seismic lines so that the cored sediment can be correlated with the seismic reflectors. For this reason, the positioning system used requires a high degree of accuracy. Core site selection also depends on the results of visual observations during collection of the cores. Where possible it is advantageous to select core locations in a grided area at the intersection of seismic profile tracklines or where the seismic reflectors are near the surface of the sea floor. This enables correlation of the seismic information and cores which can then be extrapolated laterally.

2. Field Data Collection.

A well-developed data collection plan will yield the maximum amount of data for the least expenditure of time, effort, and money. The cost of field data collection in most cases will absorb the greatest percentage of the total project costs which includes data reduction and analysis and report writing. One item which must be considered in the development of the data collection

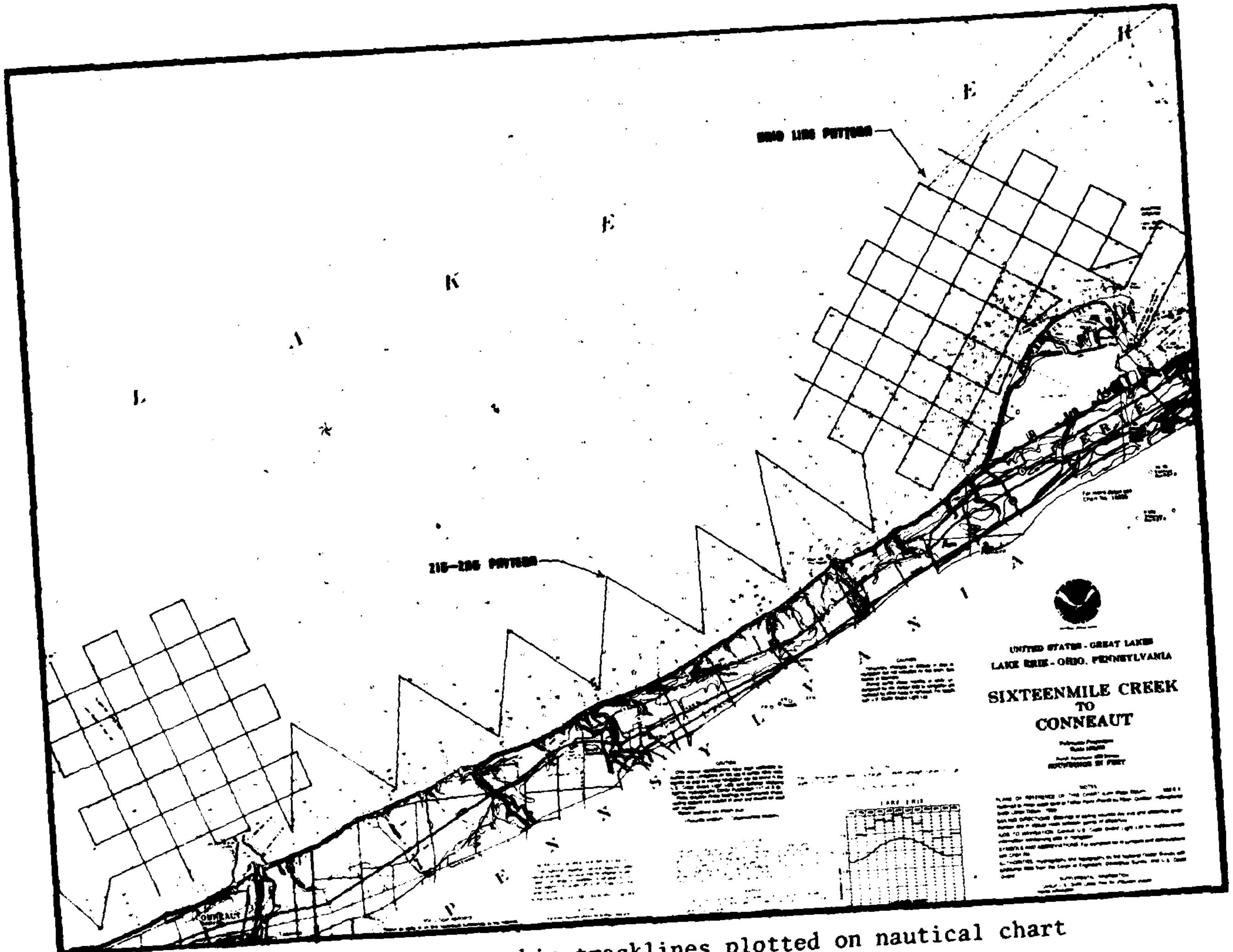

Figure 2. Tentative ship tracklines plotted on nautical chart (from NOAA chart number 14824).

work plan is the mobilization-demobilization of the various equipment components. To mobilize the seismic vessel, a port or another appropriate docking facility should be selected which can adequately accommodate the survey vessel and also provide accessibility for loading and offloading equipment from motor vehicles. An attempt should also be made to procure a survey vessel with its port of origin near the survey area. This will minimize the cost for vessel mobilization. If the survey will be conducted over a considerable stretch of coastline, an inquiry should be made of the ports within the survey area which can accommodate the survey vessel for overnight berthing. Depending on the progress of the survey, the port should be nearest the survey operations for the next workday to minimize time in getting from port to the survey area.

When the seismic data collection operations are completed, a port should be selected which will allow demobilization of the seismic survey vessel and mobilization of the coring platform. As with the seismic survey vessel, the coring platform should be procured with its port of origin near the survey area and port of mobilization. During the coring operations most of the worktime is in the running time of the coring platform from one core site to another rather than in actual core collection. Therefore, a platform with a higher running speed (10 knots or 18.3 kilometers per hour or better) would make the operation more cost-effective. Arrangements should also be made for transporting the cores to a laboratory for sampling, analysis, and subsequent storage.

A tentative daily work schedule should be developed for the field data collection operations. Allowances for adverse weather and equipment downtime should be included in the schedule. The survey should be conducted during optimum sea-state and weather conditions for the specific area. This information (frequency of storms and wave information) is available from the local office of the National Weather Service. Developing a work schedule not only coordinates the data collection but the schedule serves as a useful tool in developing cost estimates and also as a gage for measuring the survey progress. The number of days required for fieldwork must be estimated in the schedule. General guidelines for estimating the number of days required to complete the field data collection based on a 10-hour workday are listed in the Table. This table may also be used to develop U.S. Government cost estimates.

Appendix B gives an example cost estimate developed for a theoretical survey to be conducted in Lake Erie from the New York-Pennsylvania border west to Toledo, Ohio. The survey requires collecting 700 trackline miles (1,120 kilometers) of seismic and side-scan data and 150 cores. The cost estimate is based on a 60-hour workweek and does not include the cost for data reduction, data analysis, and report writing. The completed estimate is a valuable tool for deciding whether to use government plant and manpower or to contract parts or all of the survey to nongovernment companies.

Table. Guidelines for estimating number of days required for data collection operations.

Data collection operation	Time required
Mobilization of seismic vessel	1.5 to 2 days
Equipment checkout	0.5 day
Seismic data collection	35 miles (56 kilometers) of trackline per day
Contingency time (adverse weather and equipment downtime)	25 to 30 percent of estimated number of days for seismic data collection[1]
Demobilization of seismic vessel	1 day
Mobilization of coring platform	1 day
Mobilization of reconnaissance vessel	0.5 day
Collection of cores	6 to 10 cores per day (depending on core site spacing)
Contingency time	25 to 30 percent of estimated number of days for coring[1]
Demobilization of coring platform	1 day

[1]May vary with geographic area.

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APPENDIX A

LIST OF EQUIPMENT AND SPECIFICATIONS

1. Seismic operations

    a. Research vessel (essential)
    38-foot-minimum (11.6 meters) length
    40-square foot-minimum (3.7 square meters) table space
    40-square foot-minimum deck space
    110-volt a.c. power
    Compass (gyrocompass desirable)
    Marine radio
    Cruising range: 100-mile (160.9 kilometers) minimum
    Cruising speed: 10-knot minimum

    b. Subbottom profiling system

        (1) Medium resolution, high penetration (essential)
        Penetration capability 50 to 200 feet (15.2 to 61.0 meters)
        Power output 300 to 1,000 joule
        Frequency range 400 hertz to 14 kilohertz

        (2) High resolution, medium penetration (desirable)
        Penetration capability 30 to 75 feet (9.1 to 22.9 meters)
        Power output 10 kilowatts
        Frequency range 3.5 to 7 kilohertz

    c. Side-scan sonar system (desirable)
    Frequency range 95 to 100 kilohertz
    Port and starboard scanning capability
    500-foot (152.4 meters) range in either direction

    d. Geographic positioning system (essential)
    Range: 20-mile (32.2 kilometers) minimum
    Accuracy: 10 feet

    e. Microprocessor (desirable)
    Interfacing capabilities with positioning system

    f. Radios

        (1) Marine-band radio (desirable)
        (2) Two-way radio (essential)
        Range: 10-mile (16 kilometers) minimum

    g. Vehicles (essential)
    Three minimum for shore personnel

2. Coring operations

    a. Coring platform (essential)

(1) Tug and barge
Tug: capable of 8-knot (14.6 kilometers) minimum with barge in tow
Barge: 80- by 30-foot (24.4 by 9.1 meters) minimum with fore and aft anchoring capabilities, or

(2) Jack-up barge (self-propelled)
Capable of 8-knot minimum
Sufficient deck space to accommodate coring device, crane, compressor, and core storage; or

(3) Ship
Requirements same as jack-up barge

b. Reconnaissance boat (desirable)
32-foot-minimum (9.8 meters) length
10-square foot-minimum (0.9 square meter) table space
110-volt a.c. power
Compass
Cruising range: 100-mile minimum
Cruising speed: 10-knot minimum

c. Geographic positioning system
Same as 1, d

d. Coring device, pneumatic-vibrating (essential) (Tirey, 1972)
Capable of 20-foot cores (maximum)

e. Compressor (essential)
120 pounds per square inch (8.4 kilograms per square meter) at 250 cubic feet (7.1 cubic meters) per minute

f. Crane (essential)
11-short ton (10 metric tons) minimum (Baumeister, 1958)
30-foot-minimum boom length

g. Bottom grab sampler (desirable)
Various types available

h. Miscellaneous (essential)
Floats, cord, and anchor weights
Logbooks
Office supplies
Batteries
Sample bags
Waterproof markers
Tools and hardware
Cable and clamps

APPENDIX B

EXAMPLE COST ESTIMATE

Location: *Lake Erie from the New York-Pennsylvania border west to Toledo, Ohio*

Data Requirements: 700 trackline miles of seismic reflection profiles, side-scan sonar, and 150 cores

	Use	Unit cost	Item cost	Subtotal
1. Presurvey planning		$ 2,400	$ 2,400	($ 2,400)
2. Seismic operations				($ 65,225)
a. Travel and equipment transport				5,150
(1) Research vessel and crew		1,500	1,500	
(2) Seismic system				
(a) Seismic equipment and two operators		1,500	1,500	
(b) Truck rental		800	800	
(c) Electronics technician		500	500	
(3) Positioning system		250	250	
(4) Technical personnel				
(a) Project leader		200	200	
(b) Project geologist		250	250	
(c) Engineering technician		150	150	
b. Equipment and manpower				
(1) Seismic data collection				18,600
(a) Seismic system checkout and preparation (bench)		1,200	1,200	
(b) Seismic system (includes system, operators, and electronics technician		$600/day		
1 Data collection for 700 trackline miles	20 days	600/day	12,000	
2 Contingency days	5 days	600/day	3,000	
3 Mobilization and demobilization	3 days	600/day	1,800	
4 System checkout (field)	0.5 day	600/day	300	
5 Miscellaneous supplies		300	300	
(2) Side-scan sonar data collection				10,065
(a) Side-scan system checkout and preparation (bench)		500	500	
(b) Side-scan system (includes system and operators)				
1 Data collection	20 days	325/day	6,500	
2 Contingency days	5 days	325/day	1,625	
3 Mobilization and demobilization	3 days	325/day	975	
4 System checkout (field)	0.5 day	325/day	165	
5 Miscellaneous supplies		300	300	
(3) Geographic positioning data collection				16,860
(a) Positioning system checkout and preparation (bench)		0	0	
(b) Positioning system				
1 Data collection	20 days	400/day	8,000	
2 Contingency days	5 days	400/day	2,000	
3 Mobilization and demobilization	3 days	400/day	1,200	
4 System checkout (field)	0.5 day	400/day	200	
5 Shore station operators (technician and three student aids)	21 days	260/day	5,460	

(4) Research vessel (includes captain, engineer, and deckhand)				14,550
(a) Data collection	20 days	500/day	10,000	
(b) Contingency days	5 days	500/day	2,500	
(c) Mobilization and demobilization	3 days	500/day	1,500	
(d) All systems checkout	0.5 day	500/day	250	
(e) Miscellaneous expenses		300	300	
5. Coring operations				($121,680)
a. Travel and equipment transport				9,800
(1) Coring platform with crew and crane		8,600	8,600	
(2) Coring device, truck, and operator		1,200	1,200	
(3) Positioning system and technical personnel (cost included in seismic operations)		0	0	
b. Equipment and manpower				
(1) Coring platform (includes tug and barge, captain, engineer, and two deckhands)				56,975
(a) Data collection	19 days	2150/day	40,850	
(b) Contingency days	5 days	2150/day	10,750	
(c) Mobilization and demobilization	2 days	2150/day	4,300	
(d) All systems checkout	0.5 day	2150/day	1,075	
(2) Coring device (includes coring device, compressor, crange, and operator)				26,880
(a) Data collection	19 days	520/day	9,880	
(b) Contingency days	5 days	520/day	2,600	
(c) Mobilization and demobilization	2 days	520/day	1,040	
(d) Coring device checkout	0.5 day	520/day	260	
(e) Core liners	160	80 each	12,800	
(f) Miscellaneous supplies		300	300	
(3) Positioning system				15,800
(a) Data collection	19 days	400/day	7,600	
(b) Contingency days	5 days	400/day	2,000	
(c) Mobilization and demobilization	2 days	400/day	800	
(d) System checkout	0.5 day	400/day	200	
(e) Shore station operators (technician and three student aids)	20 days	260/day	5,200	
(4) Positioning boat (includes captain and fuel)				12,225
(a) Data collection	19 days	450/day	8,550	
(b) Contingency days	5 days	450/day	2,250	
(c) Mobilization and demobilization	2 days	450/day	900	
(d) All systems checkout	0.5 day	450/day	225	
(e) Miscellaneous expenses		300	300	

SUMMARY OF COST

Presurvey planning	$ 2,400
Seismic operations	65,225
Coring operations	121,680
Total project cost	$ 189,305

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